

## Why does this solution work?

The difficulty of the puzzle is perhaps made most apparent by noting that there are slightly more than 43 quintillion ( $4.3 \times 10^{19}$ ) arrangements possible for all 20 movable cubes.

How big is 43 quintillion? Well, the national debt in pennies is "only" 100 trillion. The age of the universe in seconds is thought to be only about 5 quintillion.

A very fast computer would take centuries to examine each arrangement. Yet by learning this solution and with practice, you will be able to solve the cube in a few minutes! How is this possible?

The advantage of this solution method is that by design at any time during each of the 5 steps, one is concerned with very few of the cubes involved at that step. This simplification is possible because there are fewer arrangements possible for 4 cubes (the most that are ever being dealt with at one time) than for 20 cubes. In fact, much of the time (steps 1-3), only a single cube is being dealt with. It is not difficult to keep track of just one of the 20 cubes.

In addition, the problems of positioning and orienting cubes are done separately, which significantly reduces the number of possibilities. Since there are so few arrangements of the cubes of concern at any time, it is possible to present them all and provide the appropriate action for each.

These claims can be mathematically proved, so this solution is guaranteed to be successful for solving the cube from any starting arrangement no matter how badly scrambled.

Please do not remove the colored patches from the cubes and replace them differently or take the cube apart and put it back together incorrectly! This can be done! If you do this, you will not necessarily be able to restore the cube to solid colors on all 6 faces even if you outlive the universe.

## Short cuts

After you master the cube with this solution, you will probably think it is taking too long—all of 5 minutes with practice. For those on the fast track, short cuts are provided. These vary from simple sequences of moves to expert short cuts that change the overall strategy. My preferred method of solution uses these short cuts, and I can often solve random cube problems in under 1 minute. Ambitious readers may wish to improve on this further.

Short cuts are placed in boxes at the end of each section.

## Hints

- Remember that the center cubes on each of the 6 faces do not move. They can only rotate in place. This means the proper color for each face is determined by the color of the center cube on that face. For example, the face with an orange center cube must eventually be entirely orange.
- The overall strategy of this solution is given in the summary on page 18 and 19. This puzzle is too difficult to solve without some overall strategy. Try to follow the 5 steps and remember that it often helps to correctly position a cube first and then orient it so that the colors are correct.
- As you proceed in solving the cube, it is absolutely necessary to disturb temporarily some of the cubes that are placed and oriented in previous steps. For example, after one face is completed, there is no way to accomplish anything more without temporarily disturbing some of the cubes on that now completed face. You must be daring enough to be willing to temporarily undo hard-won progress in order to continue with the solution. I found this to be the most difficult part of solving the cube for the first time. For this reason, the solution in this book was intentionally designed so that very little temporary disruption of previous progress is necessary.